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National Emergency Department Overcrowding Study tool is not useful in an Australian emergency department

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Abstract

Objective: To determine the accuracy and usefulness of the National Emergency Department Overcrowding Study (NEDOCS) tool in an urban hospital ED in Australia by direct comparison with subjective assessment by senior ED staff.

Method: A sample of simultaneous subjective and objective data pairs were collected six times a day for a period of 3 weeks. All senior medical staff in the ED answered a brief questionnaire along with the senior charge nurse for the ED. Simultaneously, the senior charge nurse also documented the total number of patients in the ED, the number of patients awaiting admission, the number of patients on ventilators, the longest time waited by an ED patient for ward bed, and the waiting time for the last patient from the Waiting Room placed on a trolley. The objective indicators were entered into a Web-based NEDOCS tool and transformed scores were compared with the averaged and transformed subjective scores for each sample time. Bland–Altmann and Kappa statistics were used to test the agreement between the objective and subjective measuring methods.

Results: The mean difference between the subjective and objective methods was small (3.5 [95% confidence interval –0.875–7.878]); however, the 95% limits of agreement was wide (–46.52–53.43). The Kappa statistic used to assess the extent of reproducibility between categorical variables was 0.31 (95% confidence interval 0.17–0.45).

Conclusion: The present study suggests that NEDOCS method of processing the objective overcrowding data does not accurately reflect the subjective assessment of the senior staff working at that time in the ED. This might be because the assumptions of the original NEDOCS study are flawed.

Key words: *Australian emergency department*, *emergency department*, *National Emergency Department Overcrowding Study tool*, *objective score*, *overcrowding*.

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Introduction

ED overcrowding is a growing issue worldwide. Over the years various articles in the press,[1,2] government reports and journals[3,4] have highlighted this issue. It was first documented in Australia in a Sydney metropolitan hospital in late 1980.[5] Overcrowding of the ED has been demonstrated to have negative effect on patient care,[6–8] staff satisfaction and health.[9,10]

Early warning of overcrowding would allow an organizational response to prevent any potential adverse outcomes. Strategies could include calling in of extra staff,[11,12] changing management strategies,[13–17] hospital ambulance bypass and notification of neighbouring hospitals. There is need for a tool, which can rapidly and accurately forewarn of overcrowding.[18]

Arguably the most accurate indicators of overcrowding are the adverse events and complaints,[19] but there is a delay in notification and correlation. They are not helpful as an early warning system.

The computerization of hospital admissions opens the possibility of a computer generated, automatic and objective warning system.[20]

Weiss and colleagues have explored the relationship of the computer-generated indicators of overcrowding with the subjective assessment by senior staff at the time of sampling. This model is called National Emergency Department Overcrowding Study (NEDOCS) tool.[21]

The NEDOCS tool was produced to 'quantitatively describe the staff's sense of overcrowding' in various sized academic ED in the USA. It was recognized that there is currently no gold standard measure of ED over crowding, so a qualitative measure of overcrowding was devised and described by same team.[22] This qualitative measure was transformed into the subjective score. The NEDOCS Tool is a Web-based calculator, which converts a simple dataset into a number (objective score) said to correlate accurately with degree of overcrowding as perceived by senior staff working at the time (subjective score). The NEDOCS tool has been developed for the use in clinical setting. It began as a 23 site-sampling questionnaire reflecting the subjective assessment of ED physicians,[22] which was then statistically reduced using mixed effect linear regression to develop a 5-questionnaire model. The validity of the reduced model was tested using a bootstrap technique and was found to reflect the full model with 88% accuracy. The NEDOCS tool was also found to correlate well with the number of patients who left without being seen[23] in further trials by the inception team.

There has been an interest in implementing the NEDOCS tool in Australia.

The objective of the present study was to assess the usefulness and accuracy of the Web-based model of the NEDOCS tool in an Australian ED compared with subjective clinician assessment.

Method

Ipswich Hospital is a 317-bed, non-tertiary urban hospital, located in Ipswich, Qld, Australia with an annual ED attendance of over 42 000. The ethics committee for Ispwich Hospital approved the study. Patient consent was not required.

The present prospective pilot study covered a sample period of 3 weeks from 20 December 2004 to 10 January 2005. Samples were collected at four hourly intervals (1.00, 5.00, 9.00, 13.00, 17.00 and 21.00 hours). The method duplicated the original paper by Weiss,[21] except that sample times were not randomized and the study was undertaken in a single hospital. The samples were collected six times a day although the study by Weiss covered each sample time twice only in the 3 week period.

The composite outcome variable score (subjective score) was calculated as follows. On each shift between one and four senior medical officers present completed a short survey, consisting of two Likert type scales (Appendices 1,2) rating the 'Degree of overcrowding' and 'Feeling of being rushed'. No instructions or definitions other than the terms presented were given. The senior charge nurse of the ED was asked independently, but simultaneously to rate the degree of overcrowding using the same scale. The senior charge nurse was not asked to rate 'Feeling of being rushed'. The even Likert scale was used so that a break point for 'not overcrowded' versus 'overcrowded' fell between 3 and 4. Each timed and dated survey form was placed in a sealed box in ED. In keeping with the Weiss[21] study, for ease of interpretation the six-point scale was converted to a scale ranging from 0 to 200 (0 = not busy, 40 = busy, 80 = extremely busy but not overcrowded, 120 = overcrowded, 160 = severely overcrowded, 200 = dangerously overcrowded).

The survey results of 'Degree of overcrowding' and 'Feeling of being rushed' were averaged for all senior physicians and charge nurse for the ED working at the time of data collection. These averaged results formed the 'outcome variable' or 'composite score'. This score comprised the subjective rating of each paired sample.

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Interrater agreement was tested retrospectively on the composite outcome data collected in the first week. The intraclass correlation coefficient was calculated for the responses to the 'feeling rushed' question asked from the doctors and then again for the 'overcrowding' question asked from the doctors and the charge nurse.

The objective rating in each sample pair was calculated by the Web-based NEDOCS Calculating Tool[24] using the following objective measurements:

1. Total number of patients in ED occupying beds. (Patients in waiting area were not included.)
2. Total number of patients on ventilators.
3. Total number of patients awaiting admission.
4. Waiting time for the last patient called in from waiting room. (Patient occupying ED bed, waiting to be seen by the physician).
5. Longest time patient waiting for admission.
6. Number of beds in ED.
7. Number of total beds (occupied and vacant) in hospital.

The first five variable objective measures were collected simultaneously and prospectively using a prepared data sheet subsequently placed in a sealed box in ED. The ED attendance screen was printed at the same time to check for the accuracy of data collection.

The NEDOCS Calculating Tool amalgamated the seven objective data points for each time of data collection and rated the data for that sample time on following scale: 0–20 = not busy, 20–60 = busy, 60–100 extremely busy but not overcrowded, 100–140 = overcrowded, 140–180 severely overcrowded, 180–200 = dangerously overcrowded.

Being a pilot study we aimed to duplicate Weiss's sample method for the same time duration as in original study,[21] rather than calculate a new sample size. However, we used different statistical analysis as we had concerns about the product moment correlation (r) coefficient used by Weiss. The valid use of correlation coefficient requires a null hypothesis stating that there is no relationship between the two statistics. This would not be the case as both subjective and objective scores are being collected at the same time to assess the same thing, that is, 'overcrowding'. In our pilot study the Bland–Altman[25,26] plot was chosen for statistical analysis, to compensate for this error. Differences between measurements within each pair were plotted on the Y-axis. The averages of the two measurements were plotted on the X-axis. The average was used, as this was the closest estimate of the true result in the absence of a gold standard for 'over-crowding'. The mean difference of all pairs was also calculated reflecting the 'estimated bias' or the systematic difference between the two methods.

Kappa statistics were used to analyse agreement between subjective and objective measures as well as assessment of interrater agreement on subjective responses.

Results

During the 3 week study period 2293 patients attended the ED, an average of 109 patients per day. For the entire 2004 calendar year, the Ipswich Hospital ED averaged 115 patients per day.

One hundred and twenty-eight sample times were described by two scores (subjective and NEDOCS) over 3 weeks. The datasets for the 3 week period were complete.

Figure 1 shows a scatter diagram of transformed subjective and objective (NEDOCS) scores. Figure 2 shows that the mean difference between the methods of measurement is small (3.47, 95% confidence interval [CI] –0.875–7.878). Figure 2 also illustrates that the range of the 95% limits of agreement are wide (–46.52–53.43).

The Bland–Altman plot shows that in 5% of the measurements, one method of measurement is likely to be more than 100-point raw score or 2.5 categories beyond the other. In the present study 16 pairs (12.5% [95% CI 7.8–19.3]) had scores more than 40 points (one whole category) apart and 49 pairs (38% [95% CI 30–46.9]) had scores in adjacent categories. The kappa value of 0.31 (95% CI 0.17–0.45) suggests poor agreement between the categorical scores.

Interrater agreement of the subjective responses used in the composite outcome score was high. The intraclass correlation coefficient was 0.87 (95% CI 0.71–0.95) for the question on 'feeling rushed'. For the 'degree of overcrowding' the intraclass correlation coefficient was 0.94 (95% CI 0.82–0.97).

Discussion

The present study demonstrates that the NEDOCS tool correlated poorly with subjective clinician assessment of overcrowding in our ED. The poor correlation is very obvious looking at Figure 2. The 95% limits of agreement are wide (more than two categories apart) making the NEDOCS tool imprecise when used in clinical setting. Such imprecision is unacceptable if one is

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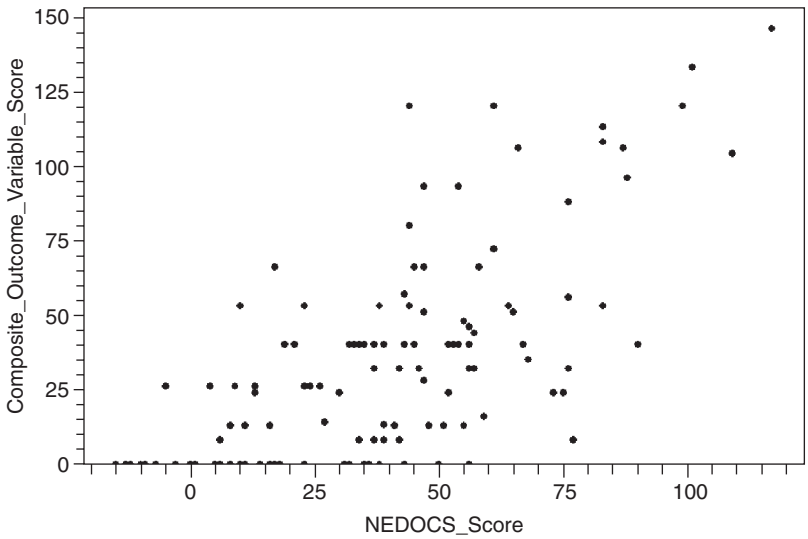

Figure 1. Scatter diagram comparison of both raw scores. (●) National Emergency Department Overcrowding Study (NEDOCS) and composite score.

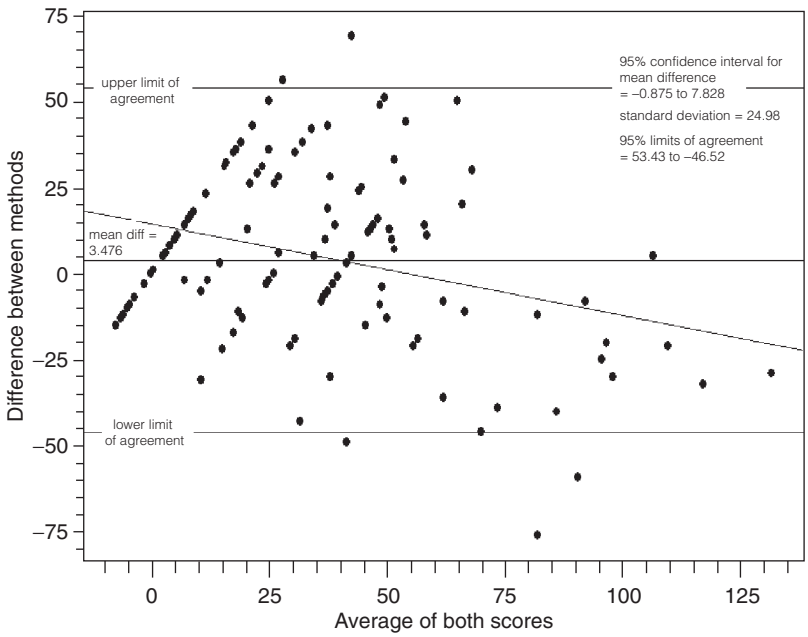

Figure 2. Bland–Altman plot.

considering up scaling hospital responses based purely on the NEDOCS score. In addition, Figure 1 shows us that there is no specific relationship between the NEDOCS and subjective scores. These findings indicate that the NEDOCS tool is not ready to be used in Australia.

Our findings might differ from Weiss's original study for several reasons. The NEDOCS tool was developed in the USA and might not be applicable in a regional Australian hospital with different patient flow and staffing profile.

The difference in findings may be partly explained by our decision to use different statistical methodology to Weiss and to interpretation of data results. Weiss used product moment correlation (r) coefficient for

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statistical analysis in their original study, and the basis of its calculation may be questioned. They concluded that the NEDOCS score accurately reflects staff's sense of 'overcrowding' quoting R^2 0.49 for the full model. The NEDOCS tool reflects the full model with 88% accuracy so it is even less accurate.

Weiss quoted a high interrater agreement (correlation coefficient 0.86–0.93) between physicians' and nurses' Likert results and between each result and the average as a justification for their use as composite outcome score. The Likert like scale used for subjective scores were developed from a preliminary survey of ED directors[22] who identified lack of ED beds, ED closure and ambulance diversion, patients managed in hallways, full waiting rooms, feeling 'rushed' and a wait of greater than 1 h to see a physician as evidence of ED overcrowding.

The statistical analysis of the data where one measurement method (subjective score) is compared with another measurement method (objective score) can be fraught with danger. When there is no gold standard to compare the new measuring tool, the statistical analysis must take into consideration the possible error of each method. For that reason we chose the Bland–Altman plot and subsequently demonstrated poor agreement.

A review of the literature highlights the difficulty in defining overcrowding. Hwang *et al.*[27] reviewed the literature over 26 years and found a total of 230 articles relating to overcrowding in the ED including original articles, reviews and editorials. Only 23 of these had explicit definitions of overcrowding. There was substantial variation in the definition of 'overcrowding in the ED' within these articles. The definitions focused on specific issues like waiting time, hospital-related but non-ED factors or factors external to the hospital such as ambulance diversions to describe overcrowding.

There is little literature documenting quantitative measurements of overcrowding in the ED.[20,21] Bernstein *et al.* developed the 'Emergency Department Work Index' (EDWIN index) which included: (i) number of patients in triage category; (ii) triage category; (iii) number of attending physicians on duty; (iv) number of treatment bays; and (v) number of admitted patients in ED. The limitation of EDWIN index is that it is not a computer-based model. It does not take into account various other issues such as the role of a resident in ED and also does not have any input from nursing staff.

Weiss *et al.*[21,22] recognized this deficit in knowledge and undertook the difficult but important task of developing a computer-based objective model. In its current form, this computer-based model NEDOCS tool has correlated poorly with staff's sense of overcrowding in our hospital. For the moment, subjective assessment seems to be the best method of assessing overcrowding until we find a better tool or refine the NEDOCS scoring method.

The NEDOCS scoring method is easy, simple and quick to use and could become a more important and useful tool with further refinement. A refined NEDOCS tool may provide us with the definitions and scoring tool we need. As Weiss suggests, measurements that include case mix within ED, triage category and skill mix of staff may improve agreement between NEDOCS score and staff's perception of 'overcrowding'.

There are several limitations to the present study. At no time during the study was the department severely or dangerously overcrowded. Correlation might be better or worse at these extreme times. The study was conducted at only one urban hospital ED with mixed children and adult presentations and might not be applicable to other systems or private ED. The biggest limitation of the present study, however, is the lack of a 'gold standard' by which to define ED overcrowding. We chose to use subjective physician/nurse assessment as the gold standard by which to measure the NEDOCS tool. It is possible that the NEDOCS tool might actually be very good, and that staff subjective assessment is actually poor.

Conclusion

The NEDOCS tool was not valid in our setting and has been inconsistent in reflecting staff's sense of 'overcrowding' for which it was primarily designed. NEDOCS is still a potentially important tool worthy of refinement.

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Author contributions

KR conceived and designed the study, collected the data and wrote the manuscript. KB assisted with some statistics and manuscript editing. SB and DM edited and assisted in writing the manuscript.

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Competing interests

None declared.

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Appendix I

Survey form for ED physician for NEDOCS tool

Date:
Please circle the time.
Time: 1 AM 5 AM 9 AM 1 PM 5 PM 9 PM

Please circle the opinion on 'Degree of Overcrowding'
1 2 3 4 5 6
1 = not busy
2 = busy
3 = extremely busy but not overcrowded
4 = overcrowded
5 = severely overcrowded
6 = dangerously overcrowded

Please circle the opinion on 'Feeling rushed' in ED
1 2 3 4 5 6
1 = not rushed
6 = rushed

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After completing the survey form, please place it into sealed box provided in Emergency Department.
ED, emergency department; NEDOCS, National Emergency Department Over Crowding Study.

Appendix II

Survey form for the charge nurse in ED for NEDOCS tool

Date:
Please circle the time.
Time: 1 AM 5 AM 9 AM 1 PM 5 PM 9 PM

Please circle the 'Degree of Overcrowding'.
1 2 3 4 5 6
1 = not busy
2 = busy
3 = extremely busy
4 = overcrowded
5 = severely overcrowded
6 = dangerously overcrowded

After completing the survey form, please place it in the sealed box provided in Emergency Department.
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